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## EUROPEAN PATENT APPLICATION

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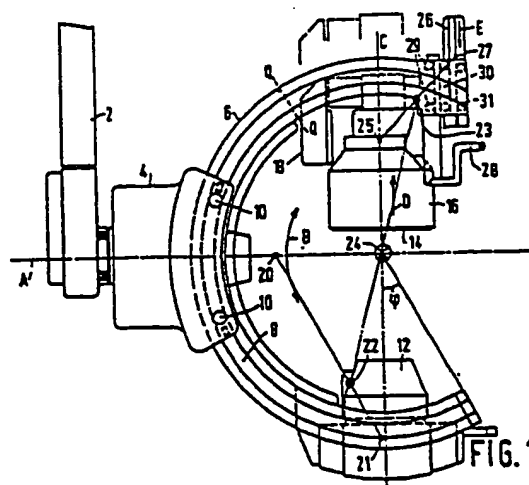
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X-ray Examination apparatus comprising a balanced supporting arm.

An X-ray examination apparatus for irradiating an object in different directions comprises an X-ray source (12), an X-ray detector (16) and a counterweight (26), secured to a C-shaped support (6). The counterweight is situated at that end of the arm which also carries the X-ray detector. The movement of the counterweight is such that for all positions of the X-ray detector the centre of gravity of the support, the X-ray source, the X-ray detector and the counterweight is situated in the point (24) of intersection of the axes of rotation ((the isocentre). As a result, the support is continuously balanced and manual adjustment of the support is possible. Balancing is facilitated by a cast and hence light C-arc.



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# X-ray examination apparatus comprising a balanced supporting arm.

The invention relates to an X-ray examination apparatus, comprising a vertical column, a sleeve which is connected to the column and which is rotatable about a first horizontal axis, and a C-shaped support which is carried by the sleeve and which is movable in the sleeve about a second axis which intersects the first axis at right angles, said C-shaped support accommodating an X-ray source at a first end and an X-ray detector at a second end, which X-ray detector is movable along a central ray of an X-ray beam to be emitted by the X-ray source.

An X-ray examination apparatus for irradiating an object in different directions is known from United States Patent Specification US 3,281,598.

In an X-ray examination apparatus described therein combined rotation of the X-ray source and the X-ray detector, connected to a two-armed support, takes place about three axes which intersect one another at right angles in one point (the isocentre) which is situated between the X-ray source and the X-ray detector. The known X-ray examination apparatus, however, is not balanced and the locking in positions in which the two-armed support is rotated out of a vertical plane about a first horizontal axis is provided by an electric motor and a gearwheel transmission. Movement of the two-armed support in the sleeve under the influence of the force of gravity is prevented by an electric motor which locks the arm in the sleeve for a given irradiation direction. Manual adjustment of the direction of irradiation, however, is obstructed thereby. In order to prevent the non-balanced, comparatively heavy X-ray detector, for example an X-ray image intensifier tube, from colliding with the support or an object to be examined upon displacement along the central ray, for example for adjusting an enlargement, the X-ray examination apparatus usually comprises a protection mechanism.

It is an object of the invention to provide a compact X-ray examination apparatus of comparatively simple construction for irradiating an object from different directions, in which an X-ray source and an X-ray detector are arranged opposite one another, and in which the positions of the X-ray source and the direction of irradiation are manually adjustable without substantial effort.

To achieve this, an X-ray examination apparatus of the kind set forth in accordance with the invention is characterized in that a shift of a centre of gravity of the X-ray detector which occurs upon displacement of the X-ray detector along the central ray is substantially compensated for by way of a counterweight which is secured to the second end of the support and whose direction of move-

ment opposes that of the X-ray detector, in that a common centre of gravity of the support, the X-ray source, the X-ray detector and the counterweight is situated on the second axis for an adjustable range of distances between the X-ray detector and the X-ray source, and in that a common centre of gravity of the sleeve, the support, the X-ray detector, the X-ray source and the counterweight is situated on the first horizontal axis for an adjustable range of distances between the X-ray detector and the X-ray source.

It is to be noted that the balancing of the motion of the X-ray detector by means of a counterweight which moves in the opposite direction is known per se from United States Patent Specification US 3,892,967.

In the apparatus described in the cited Patent Specification a two-armed support is formed by a pivotable parallelogram construction comprising an X-ray source and an X-ray detector which are situated opposite one another on two long projecting arms. The counterweight moves, via a pulley construction, along one of the short side arms interconnecting the projecting arms in the parallelogram construction. For the balancing of such an X-ray examination apparatus, correct adaptation of weight and position of the X-ray source, the X-ray detector, the balancing weight and the support is less critical than for the balancing of a C-shaped support. The common centre of gravity of all parts can be situated in a position on the first axis of rotation by adding balancing weights to the parallelogram construction. No additional balancing weights may be added to the C-shaped support which must be capable of moving freely in the sleeve, and adaptation of the centres of gravity of the C-shaped support, the X-ray source, the X-ray detector and the balancing weight so that the common centre of gravity thereof is situated on the second axis of rotation is essential.

A preferred embodiment of an X-ray examination apparatus in accordance with the invention is characterized in that the C-shaped support is formed by a tubular profile provided with two running surfaces on an outer side, which profile comprises internal partitions, said profile, running surfaces and partitions being formed by a single casting having a wall thickness of between approximately 8 and 5 mm.

By casting the support as an integral unit having a comparatively small wall thickness, the number of operations required for manufacturing the support is reduced; moreover, the small wall thickness of the casting enables fast dissipation of heat from the casting after the casting process, so that a

comparatively light and high-quality casting is obtained as a result of the fast cooling. Because of the comparatively large saving in weight enabled by the casting process, the load exerted on the sleeve, the C-shaped support itself and the vertical suspension is comparatively low, and facilitates balancing.

The invention will be described in detail hereinafter with reference to the accompanying drawing; therein

Fig. 1a is a side elevation of an X-ray examination apparatus,

Fig. 1b is a diagrammatic plan view of an X-ray examination apparatus,

Fig. 2 diagrammatically illustrates the movement of the X-ray detector and the counterweight, and

Fig. 3 is a cross-sectional view of a cast C-shaped support.

Fig. 1 shows a vertical column 2 and a sleeve 4 secured thereto. The sleeve 4 is rotatable about an axis A and supports a two-armed support 6 (in this case in the form of a C-arc). The support 6 is provided on both sides with slots 8 (only one of which is visible in the Figure) in which there are arranged bearing wheels 10, and is movable in the sleeve 4 in the direction of an arrow B. At one end of the support 6 there is situated an X-ray source 12 which emits an X-ray beam which is incident on an entrance screen 14 of an X-ray image intensifier tube 16. The X-ray image intensifier tube 16 converts an X-ray image of a body arranged between the X-ray source 12 and the X-ray detector 16 into a visible image which is detected by means of a video camera 18. The centre of gravity of the support 6 is situated in a position 20, the common centre of gravity of the X-ray source 12 and the support 6 being situated in a point 22. The X-ray image intensifier tube 25 has a centre of gravity in a position 25, a counterweight 26 having a centre of gravity in a position 27. Movement of the X-ray image intensifier tube 16 parallel to the axis C is guided by wheels 29, transmission means 30 transferring to the counterweight 26 a motion of the X-ray image intensifier tube in the opposite direction. A movement of the counterweight 26 is guided by wheels 31. When the X-ray image intensifier tube 16 is moved in the direction of an arrow D by means of a grip 28 connected to the X-ray image intensifier tube, the counterweight 26 coupled to the X-ray image intensifier tube is moved in the direction of an arrow E. As a result, the common centre of gravity of the X-ray image intensifier tube and the counterweight remains in the position 23 and the common centre of gravity of the support 6, the X-ray source 12 and the combination formed by the X-ray image intensifier tube and the counterweight remains in the position 24 which is situ-

ated on the second axis of rotation which extends perpendicularly to the plane of drawing. Because the centre of gravity remains situated on the second axis of rotation during movement of the arm 6 in the direction of the arrow B, little effort will be required for this operation. The common centre of gravity of the sleeve 4, the arm 6, the X-ray source 12 and the combination formed by the image intensifier tube and the counterweight is situated on the axis A, so that the X-ray examination apparatus is balanced during rotation about the axis A.

Fig. 1b is a plan view of the sleeve 4 and the support 6. When the common centre of gravity of the support, the X-ray detector and the counterweight is situated in a position 24 on the second axis F, the centre of gravity of the sleeve 4 is situated in a position 50 so that the common centre of gravity is situated in a position 52 on the first horizontal axis A.

Fig. 2 diagrammatically illustrates the coupling of the movement of the X-ray image intensifier tube and the counterweight. For example, via a drive belt or chain 36 which extends in a closed loop around two pulleys 38 and whereto the X-ray image intensifier tube as well as the counterweight are secured, the movement of the X-ray image intensifier tube is transferred to the counterweight in the opposite direction.

Fig. 3 is a cross-sectional view of a C-shaped support, taken along a line Q-Q in Fig. 1. The wall thickness of an inner side 8 and an outer side 10 of the casting amounts to 5 mm, the thickness of the side walls being 8 mm. As a result of the U-shaped recessed running surfaces 11 and the curvature of the inner side 8, the profile has an optimum stiffness to weight ratio. In the centre of a number of partitions 12, being arranged at regular distances from one another in the support 6 and having a wall thickness of, for example 6 mm, there is provided an opening for the passage of cables, for example for powering the X-ray source or for transporting X-ray detector signals. After completion of the casting, holes will be present in the running surfaces 11 at areas where casting cores for securing and correct positioning project through the wall 11. After casting, these holes are closed by welding and the surface of the running faces 11, being formed with a high casting quality and having a comparatively low porosity, are subjected to a finishing operation, if necessary. The outer sides of the walls 8 and 10 may be sandblasted. The supporting arm is preferably made of cast AlSi10Mg-(Cu)WA or AlZn10Si8Mg or equivalent, comparatively light materials. AlZn10Si8Mg has the advantage of cold hardening, so that it is not necessary to harden the C-shaped supporting arm in, for example an oven.

## Claims

1. An X-ray examination apparatus, comprising a vertical column, a sleeve which is connected to the column and which is rotatable about a first horizontal axis, and a C-shaped support which is carried by the sleeve and which is movable in the sleeve about a second axis which intersects the first axis at right angles, said C-shaped support accomodating an X-ray source at a first end and an X-ray detector at a second end, which X-ray detector is movable along a central ray of an X-ray beam to be emitted by the X-ray source, characterized in that a shift of a centre of gravity of the X-ray detector which occurs upon displacement of the X-ray detector along the central ray is substantially compensated for by way of a counterweight which is secured to the second end of the support and whose direction of movement opposes that of the X-ray detector, in that a common centre of gravity of the support, the X-ray source, the X-ray detector and the counterweight is situated on the second axis for an adjustable range of distances between the X-ray detector and the X-ray source, and in that a common centre of gravity of the sleeve, the support, the X-ray detector, the X-ray source and the counterweight is situated on the first horizontal axis for an adjustable range of distances between the X-ray detector and the X-ray source.

2. An X-ray examination apparatus as claimed in Claim 1, characterized in that the C-shaped support is formed by a tubular profile provided with two running surfaces on an outer side, which profile comprises internal partitions, said profile, running surfaces and partitions being formed by a single casting having a wall thickness of between approximately 8 and 5 mm.

3. An X-ray examination apparatus as claimed in Claim 1, characterized in that the X-ray detector is formed by an X-ray image intensifier tube.

4. An X-ray examination apparatus as claimed in Claim 2, characterized in that the C-shaped support contains one of the alloys G-AISI10Mg-(CU)WA and G-AIZn10si8Mg.

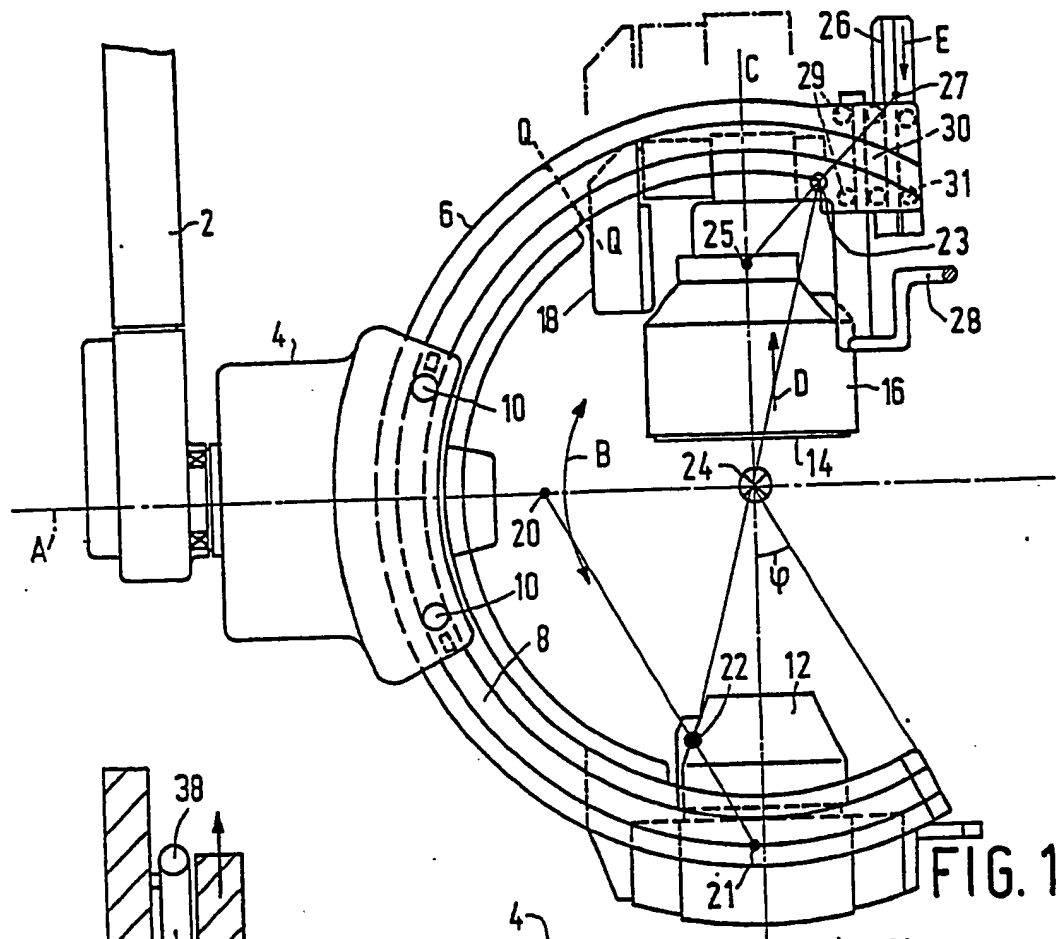


FIG. 1

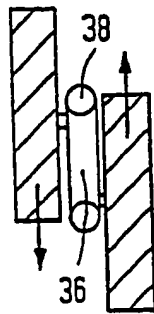


FIG. 2

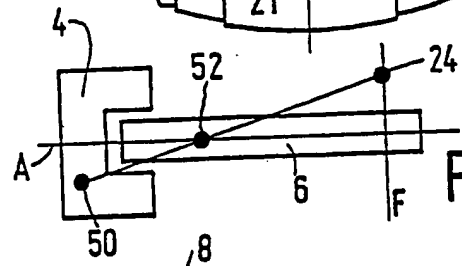


FIG. 1b

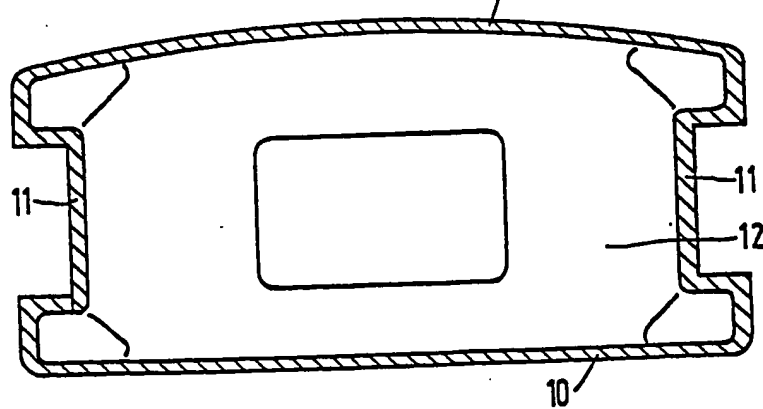


FIG. 3



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# EUROPEAN SEARCH REPORT

Application Number

EP 89 20 1776

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
Y	GB-A-1 175 032 (ETS. DE MAN) * Page 1, line 75 - page 2, line 18; page 2, lines 73-79; figures 1-3 *	1,3	A 61 B 6/00
A	---	2	
Y	US-A-4 363 128 (J.K. GRADY) * Abstract; column 2, lines 20-46,59-68; column 3, line 55 - column 4, line 12; figures 1,2 *	1,3	
D,A	US-A-3 281 598 (O.C. HOLLSTEIN) * Abstract; column 7, lines 22-46,55-67; column 8, lines 3-56; figures 1,8 *	1-3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			A 61 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 16-10-1989	Examiner RIEB K.D.
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			



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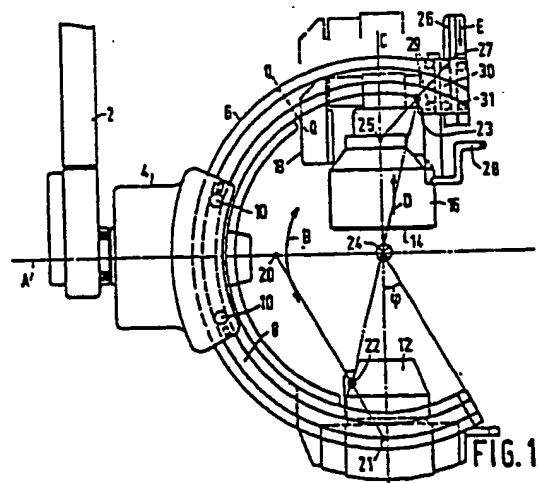
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(54) X-ray Examination apparatus comprising a balanced supporting arm.

(57) An X-ray examination apparatus for irradiating an object in different directions comprises an X-ray source (12), an X-ray detector (16) and a counterweight (26), secured to a C-shaped support (6). The counterweight is situated at that end of the arm which also carries the X-ray detector. The movement of the counterweight is such that for all positions of the X-ray detector the centre of gravity of the support, the X-ray source, the X-ray detector and the counterweight is situated in the point (24) of intersection of the axes of rotation ((the isocentre). As a result, the support is continuously balanced and manual adjustment of the support is possible. Balancing is facilitated by a cast and hence light C-arc.



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# X-ray examination apparatus comprising a balanced supporting arm.

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An X-ray examination apparatus for irradiating an object in different directions is known from United States Patent Specification US 3,281,598.

In an X-ray examination apparatus described therein combined rotation of the X-ray source and the X-ray detector, connected to a two-armed support, takes place about three axes which intersect one another at right angles in one point (the isocentre) which is situated between the X-ray source and the X-ray detector. The known X-ray examination apparatus, however, is not balanced and the locking in positions in which the two-armed support is rotated out of a vertical plane about a first horizontal axis is provided by an electric motor and a gearwheel transmission. Movement of the two-armed support in the sleeve under the influence of the force of gravity is prevented by an electric motor which locks the arm in the sleeve for a given irradiation direction. Manual adjustment of the direction of irradiation, however, is obstructed thereby. In order to prevent the non-balanced, comparatively heavy X-ray detector, for example an X-ray image intensifier tube, from colliding with the support or an object to be examined upon displacement along the central ray, for example for adjusting an enlargement, the X-ray examination apparatus usually comprises a protection mechanism.

It is an object of the invention to provide a compact X-ray examination apparatus of comparatively simple construction for irradiating an object from different directions, in which an X-ray source and an X-ray detector are arranged opposite one another, and in which the positions of the X-ray source and the direction of irradiation are manually adjustable without substantial effort.

To achieve this, an X-ray examination apparatus of the kind set forth in accordance with the invention is characterized in that a shift of a centre of gravity of the X-ray detector which occurs upon displacement of the X-ray detector along the central ray is substantially compensated for by way of a counterweight which is secured to the second end of the support and whose direction of move-

ment opposes that of the X-ray detector, in that a common centre of gravity of the support, the X-ray source, the X-ray detector and the counterweight is situated on the second axis for an adjustable range of distances between the X-ray detector and the X-ray source, and in that a common centre of gravity of the sleeve, the support, the X-ray detector, the X-ray source and the counterweight is situated on the first horizontal axis for an adjustable range of distances between the X-ray detector and the X-ray source.

It is to be noted that the balancing of the motion of the X-ray detector by means of a counterweight which moves in the opposite direction is known per se from United States Patent Specification US 3,892,967.

In the apparatus described in the cited Patent Specification a two-armed support is formed by a pivotable parallelogram construction comprising an X-ray source and an X-ray detector which are situated opposite one another on two long projecting arms. The counterweight moves, via a pulley construction, along one of the short side arms interconnecting the projecting arms in the parallelogram construction. For the balancing of such an X-ray examination apparatus, correct adaptation of weight and position of the X-ray source, the X-ray detector, the balancing weight and the support is less critical than for the balancing of a C-shaped support. The common centre of gravity of all parts can be situated in a position on the first axis of rotation by adding balancing weights to the parallelogram construction. No additional balancing weights may be added to the C-shaped support which must be capable of moving freely in the sleeve, and adaptation of the centres of gravity of the C-shaped support, the X-ray source, the X-ray detector and the balancing weight so that the common centre of gravity thereof is situated on the second axis of rotation is essential.

A preferred embodiment of an X-ray examination apparatus in accordance with the invention is characterized in that the C-shaped support is formed by a tubular profile provided with two running surfaces on an outer side, which profile comprises internal partitions, said profile, running surfaces and partitions being formed by a single casting having a wall thickness of between approximately 8 and 5 mm.

By casting the support as an integral unit having a comparatively small wall thickness, the number of operations required for manufacturing the support is reduced; moreover, the small wall thickness of the casting enables fast dissipation of heat from the casting after the casting process, so that a



comparatively light and high-quality casting is obtained as a result of the fast cooling. Because of the comparatively large saving in weight enabled by the casting process, the load exerted on the sleeve, the C-shaped support itself and the vertical suspension is comparatively low, and facilitates balancing.

The invention will be described in detail hereinafter with reference to the accompanying drawing; therein

Fig. 1a is a side elevation of an X-ray examination apparatus,

Fig. 1b is a diagrammatic plan view of an X-ray examination apparatus,

Fig. 2 diagrammatically illustrates the movement of the X-ray detector and the counterweight, and

Fig. 3 is a cross-sectional view of a cast C-shaped support.

Fig. 1 shows a vertical column 2 and a sleeve 4 secured thereto. The sleeve 4 is rotatable about an axis A and supports a two-armed support 6 (in this case in the form of a C-arc). The support 6 is provided on both sides with slots 8 (only one of which is visible in the Figure) in which there are arranged bearing wheels 10, and is movable in the sleeve 4 in the direction of an arrow B. At one end of the support 6 there is situated an X-ray source 12 which emits an X-ray beam which is incident on an entrance screen 14 of an X-ray image intensifier tube 16. The X-ray image intensifier tube 16 converts an X-ray image of a body arranged between the X-ray source 12 and the X-ray detector 16 into a visible image which is detected by means of a video camera 18. The centre of gravity of the support 6 is situated in a position 20, the common centre of gravity of the X-ray source 12 and the support 6 being situated in a point 22. The X-ray image intensifier tube 25 has a centre of gravity in a position 25, a counterweight 26 having a centre of gravity in a position 27. Movement of the X-ray image intensifier tube 16 parallel to the axis C is guided by wheels 29, transmission means 30 transferring to the counterweight 26 a motion of the X-ray image intensifier tube in the opposite direction. A movement of the counterweight 26 is guided by wheels 31. When the X-ray image intensifier tube 16 is moved in the direction of an arrow D by means of a grip 28 connected to the X-ray image intensifier tube, the counterweight 26 coupled to the X-ray image intensifier tube is moved in the direction of an arrow E. As a result, the common centre of gravity of the X-ray image intensifier tube and the counterweight remains in the position 23 and the common centre of gravity of the support 6, the X-ray source 12 and the combination formed by the X-ray image intensifier tube and the counterweight remains in the position 24 which is situ-

ated on the second axis of rotation which extends perpendicularly to the plane of drawing. Because the centre of gravity remains situated on the second axis of rotation during movement of the arm 6 in the direction of the arrow B, little effort will be required for this operation. The common centre of gravity of the sleeve 4, the arm 6, the X-ray source 12 and the combination formed by the image intensifier tube and the counterweight is situated on the axis A, so that the X-ray examination apparatus is balanced during rotation about the axis A.

Fig. 1b is a plan view of the sleeve 4 and the support 6. When the common centre of gravity of the support, the X-ray detector and the counterweight is situated in a position 24 on the second axis F, the centre of gravity of the sleeve 4 is situated in a position 50 so that the common centre of gravity is situated in a position 52 on the first horizontal axis A.

Fig. 2 diagrammatically illustrates the coupling of the movement of the X-ray image intensifier tube and the counterweight. For example, via a drive belt or chain 36 which extends in a closed loop around two pulleys 38 and whereto the X-ray image intensifier tube as well as the counterweight are secured, the movement of the X-ray image intensifier tube is transferred to the counterweight in the opposite direction.

Fig. 3 is a cross-sectional view of a C-shaped support, taken along a line Q-Q in Fig. 1. The wall thickness of an inner side 8 and an outer side 10 of the casting amounts to 5 mm, the thickness of the side walls being 8 mm. As a result of the U-shaped recessed running surfaces 11 and the curvature of the inner side 8, the profile has an optimum stiffness to weight ratio. In the centre of a number of partitions 12, being arranged at regular distances from one another in the support 6 and having a wall thickness of, for example 6 mm, there is provided an opening for the passage of cables, for example for powering the X-ray source or for transporting X-ray detector signals. After completion of the casting, holes will be present in the running surfaces 11 at areas where casting cores for securing and correct positioning project through the wall 11. After casting, these holes are closed by welding and the surface of the running faces 11, being formed with a high casting quality and having a comparatively low porosity, are subjected to a finishing operation, if necessary. The outer sides of the walls 8 and 10 may be sandblasted. The supporting arm is preferably made of cast AISi10Mg-(Cu)WA or AlZn10Si8Mg or equivalent, comparatively light materials. AlZn10Si8Mg has the advantage of cold hardening, so that it is not necessary to harden the C-shaped supporting arm in, for example an oven.

## Claims

1. An X-ray examination apparatus, comprising a vertical column, a sleeve which is connected to the column and which is rotatable about a first horizontal axis, and a C-shaped support which is carried by the sleeve and which is movable in the sleeve about a second axis which intersects the first axis at right angles, said C-shaped support accomodating an X-ray source at a first end and an X-ray detector at a second end, which X-ray detector is movable along a central ray of an X-ray beam to be emitted by the X-ray source, characterized in that a shift of a centre of gravity of the X-ray detector which occurs upon displacement of the X-ray detector along the central ray is substantially compensated for by way of a counterweight which is secured to the second end of the support and whose direction of movement opposes that of the X-ray detector, in that a common centre of gravity of the support, the X-ray source, the X-ray detector and the counterweight is situated on the second axis for an adjustable range of distances between the X-ray detector and the X-ray source, and in that a common centre of gravity of the sleeve, the support, the X-ray detector, the X-ray source and the counterweight is situated on the first horizontal axis for an adjustable range of distances between the X-ray detector and the X-ray source.

2. An X-ray examination apparatus as claimed in Claim 1, characterized in that the C-shaped support is formed by a tubular profile provided with two running surfaces on an outer side, which profile comprises internal partitions, said profile, running surfaces and partitions being formed by a single casting having a wall thickness of between approximately 8 and 5 mm.

3. An X-ray examination apparatus as claimed in Claim 1, characterized in that the X-ray detector is formed by an X-ray Image Intensifier tube.

4. An X-ray examination apparatus as claimed in Claim 2, characterized in that the C-shaped support contains one of the alloys G-AlSi10Mg-(Cu)WA and G-AlZn10Si8Mg.

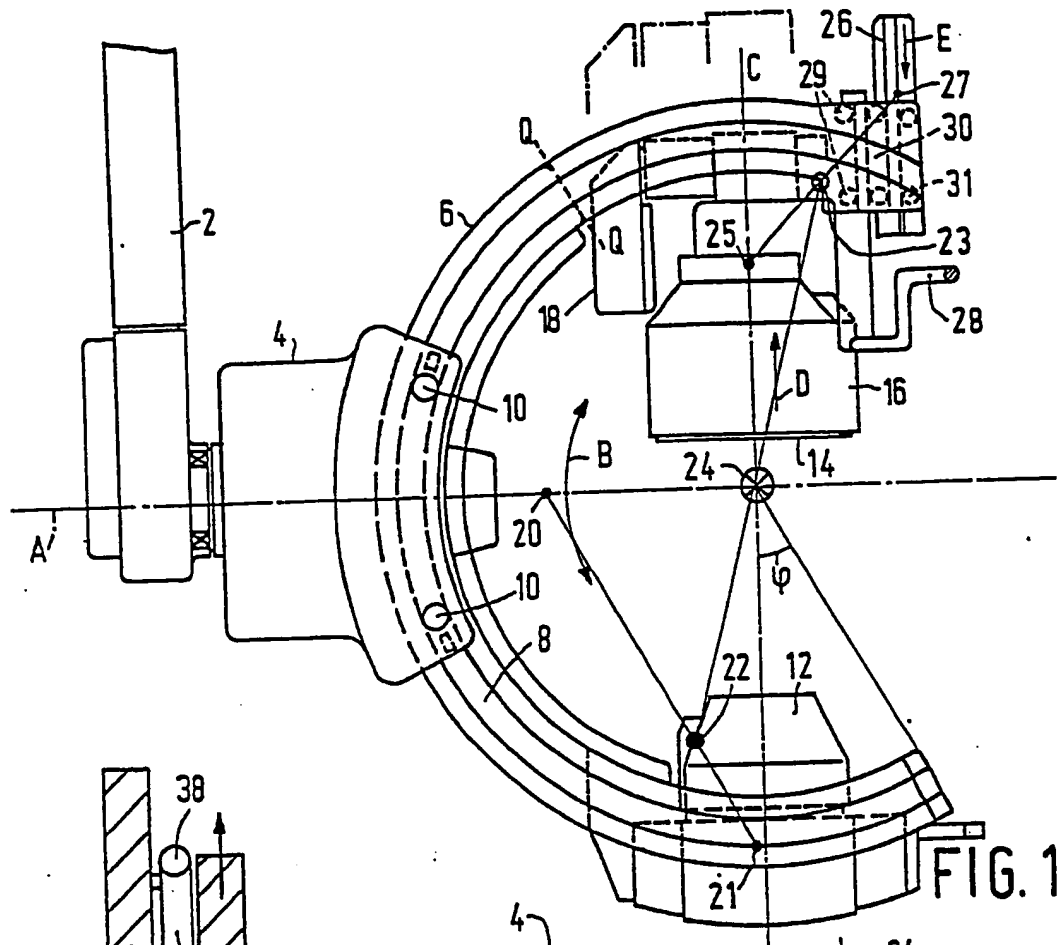


FIG. 1

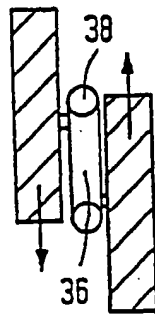


FIG. 2

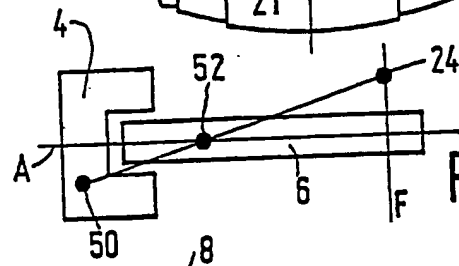


FIG. 1b

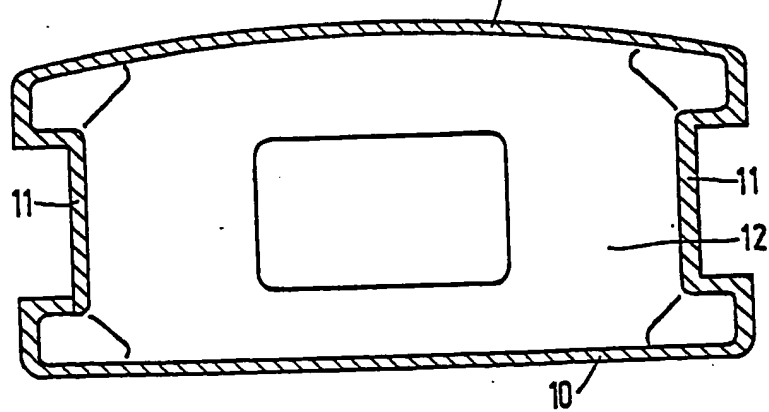


FIG. 3



European Patent  
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# EUROPEAN SEARCH REPORT

Application Number

EP 89 20 1776

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	GB-A-1 175 032 (ETS. DE MAN) * Page 1, line 75 - page 2, line 18; page 2, lines 73-79; figures 1-3 *	1,3	A 61 B 6/00
A	---	2	
Y	US-A-4 363 128 (J.K. GRADY) * Abstract; column 2, lines 20-46,59-68; column 3, line 55 - column 4, line 12; figures 1,2 *	1,3	
D,A	US-A-3 281 598 (O.C. HOLLSTEIN) * Abstract; column 7, lines 22-46,55-67; column 8, lines 3-56; figures 1,8 *	1-3	
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			A 61 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 16-10-1989	Examiner RIEB K.D.
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			